enerSave

For Municipalities

Financial Analysis of Conservation Measures

Energy, Mines and Resources Canada   Énergie, Mines et Ressources Canada

5

enerSave
For Municipalities

Financial Analysis of Conservation Measures

Contents

Introduction

1 Capital Budgeting 1

2 Simple Pay-back Analysis: A Quick Approach 2

3 The Concept of Present Worth 3

4 Using Discounted Cash Flow Analysis to Minimize Costs 4

5 Choosing a Discount Rate for Project Evaluation 5

6 Project Analysis and Inflation 7

7 Net Present Value — An Alternative Evaluation Technique 8

8 The Problem of Different Life Expectancies 9

9 Calculating Project Costs — A Cautionary Note 10

10 Social Benefits and Social Costs 10

Sources 13

For further information, contact your provincial department of energy or the Department of Energy, Mines and Resources, Ottawa.

Cat. No. M22-68/1982-5E
ISBN 0-662-11896-0

Financial Analysis of Conservation Measures

Introduction

With rising energy prices the significance of energy-related expenses in institutional budgeting has also increased. Decisions affecting levels of energy use now have greater consequences for the municipality, and it is increasingly important that these decisions be based on careful analyses of available alternatives.

The municipal politician or civil servant faces difficult choices. A more energy-efficient municipal building built today may mean that capital funds for a playground will not be available. However, a building constructed with low first costs and high energy consumption levels implies higher energy costs in the future, and could thus lower the amount of municipal funds available for capital projects later.

In many situations trade-offs of this nature exist between initial capital costs and on-going energy costs. In other words, expenditures can be made now in return for lowered energy bills in the future. The municipal decision-maker must be able to determine how much capital it is worthwhile to invest now to reduce future energy-related expenditures.

This section will sketch several techniques for investment analysis and illustrate their application. The object is to provide the reader with a sufficient background in capital budgeting to request appropriate project analyses from staff, and to review studies with a reasonable understanding of their long-term implications. The text is only introductory. For those wishing to undertake their own analysis, references are provided to publications that will supply detailed information on the application of these decision-making tools.

The text focuses on the basic concepts necessary for project evaluation and selection. But even the best evaluation techniques will not result in the best response if opportunities for change are not recognized or if technical solutions are faulty. Making the best use of available capital funds requires a determined effort to generate new ideas and to take advantage of growing technical knowledge in the field of conservation.

1- Capital Budgeting

Because our focus is energy cost, this discussion concentrates on the problem of trading off high capital costs now for lower operating costs, specifically lower energy costs, later*. For example, portions of the capital budget may be used to retrofit public buildings, thus lowering future energy bills. Alternatively, the tender specifications for new buildings may be changed to improve the anticipated energy performance despite a resulting higher capital cost. Adequate capital budgeting will ensure that the trade-offs in total costs are examined, improving the decision-making process and resulting in better choices.

The decision-making problems of municipalities, in many situations, can be seen to involve two steps:

- determining the quantity and quality of the service to be provided
- minimizing the cost of providing the chosen quantity and quality of that service

To take a very simple example, municipal officials will specify standards for temperature, ventilation and humidity levels in a new building. This is a choice about service level and quality. Having established these standards, their problem is to select heating fuels, mechanical systems and insulation levels to maintain these standards while minimizing the energy services bill.

Municipal services provide another illustration of this choice. It may be necessary, for instance, to expand garbage collection to a new subdivision and to

* In some cases, the trade-off may involve higher labour costs and lower energy costs (e.g. improved maintenance).

decide on the number of collections weekly. The level of service established will influence decisions regarding purchase of new equipment, employment of new staff and/or increasing fuel consumption. Having decided on the schedule, the municipality must then determine the most efficient way of meeting these new requirements - by rationalizing existing services, perhaps, or by purchasing energy-efficient equipment.

In the decision-making process, there will be a natural feedback between the service level chosen and the ensuing costs. For example, a public building such as a skating rink may be initially planned for a certain capacity. If, however, cost estimates prove much higher than anticipated, the plans may be scaled down.

In addition to costs, contending community needs and political considerations very much affect decisions regarding the provision of municipal services. To simplify discussion, therefore, this section begins by assuming that service levels have been decided and that the problem is to minimize the costs of providing these specified services.

The fundamental problem municipalities face in analyzing the costs and benefits of alternative or competing projects is that expenditures occur at different points in time. Most projects will normally involve a stream of expenditures and receipts (cash flow) that occur over many years. Initial expenditures may consist of the outlays for buildings and/or equipment, including wage costs involved in installation or construction. And most capital projects will also affect ongoing operating, maintenance and administration (OMA) costs.*

This, then, is one problem - to analyze correctly which project among competing alternatives offers the minimum overall costs for the municipality. To do so, officials must be in a position to compare total expenditures incurred by each option over the life of the project. In the case of energy-conserving capital expenditures, the problem comes down to whether or not the additional capital expenditures being considered lower annual OMA expenditures sufficiently to make the investment worthwhile.

For this analysis it is critically important that the benefits from the compared projects be identical. If, and only if, the projects offer essentially identical services to the municipality is a direct comparison of costs meaningful. In another situation, a municipality may be deciding between a new park or a new road. In this case the difference between expenditures on the park and on the road will not be the determining factor in reaching a decision, since the services to be provided and the beneficiaries of those services are very different. This situation illustrates a second problem which will be addressed later.

2- Simple Pay-back Analysis: A Quick Approach

The simple pay-back period is one technique used to evaluate the financial attractiveness of energy savings from capital investments. A useful rule of thumb, the pay-back period is simply the number of years required for the dollar value of energy savings to equal the expenditure of capital funds (taking into account any increase in other OMA costs caused by the investment).

The following example is very simple. The municipality is contemplating adding insulation at an installed cost of $1,000. This might be the cost of retrofitting an existing building with additional insulation, or the capital cost associated with improving energy efficiency of a building currently in the design stage.

Since no additional operating costs result from improving the insulation in this example, a quick calculation shows that, with energy savings of $200, the investment is paid back in five years*.

---

* Energy conservation projects lower energy costs, which are a component of OMA costs. They may also increase or decrease other OMA costs (e.g. the wage bill when improved equipment maintenance schedules are introduced). As this chapter illustrates basic principles, we will ignore all but the energy component of OMA expenditures. In actual project analysis all cost changes arising from the project should be considered in project evaluation.

* If instead the municipality had to pay an extra $50 per year in manpower costs, the net savings would only be $150 ($200-$50) and the pay-back period 6.67 years ($1,000 divided by $150).

TABLE 1

Project: Calculation of Pay-back Period

INSULATION INVESTMENT

Contract costs	$1,000
Energy savings	200 gallons of fuel oil per annum
Cost per gallon	1 dollar
Additional operating and maintenance	0 dollar
Value of Energy savings per year	$200
PAY-BACK PERIOD:	$\frac{\text{Costs}}{\text{Value of energy savings per year}}$ = 5 years

In actually applying pay-back analysis a number of factors must be considered. First, results depend heavily upon the assumed price of the energy being saved, and predicting energy prices is difficult in the current environment. If today's price is used to value future energy savings the analyst would be adopting a very conservative stance, with the investment looking less attractive than it really is. Inflation is now running in the range of 10-12 percent, and fuel costs will likely rise more quickly than the inflation rate. To get a reasonable estimate of the pay-back period, anticipated energy price changes should be built into the estimate.

Secondly, it is often useful to consider several options, not just one as was the case in this example. For instance, it might be worthwhile to investigate installing 1.5 times or twice the proposed amount of insulation to see how the pay-back period would vary with changes in the proposed capital investment. And of course it is crucial that technical estimates of energy savings be realistic. Unless the technical work is solid, the economic analysis is misleading.

Apart from its usefulness in the preliminary evaluation of projects, the pay-back technique can be used to publicize potential energy savings from municipal projects.

3- The Concept of Present Worth

While pay-back is a useful rule of thumb, simple pay-back is not a good tool for making investment decisions. For instance, it is impossible to rank projects from best to worst on this basis: with two competing projects it cannot be guaranteed that a project that pays back in two years is a superior project to one that pays back in three years.

Both individuals and organizations, for instance, have opportunities to invest money and earn a return on their investment. These opportunities provide a standard to judge whether an energy conservation project is worthwhile. Only if conservation projects offer benefits at least as good as other investment opportunities should these projects be accepted.

The opportunity to borrow or lend at market rates of interest means that one dollar is worth less at a future point than it is today. It is therefore essential to evaluate future benefits and costs of all investment opportunities in terms of their current value, or their present worth.

For instance, if an investor purchases a five-year certificate for $1,000, and a bank or trust company agrees to pay 12% interest compounded annually*, the purchaser will receive $1,762 at the end of the five-year period. In other words, the purchaser has traded $1,000 of 1980 (today's) dollars for $1,762 of 1985 (tomorrow's) dollars.

The present worth of 1985 dollars, measured in 1980 dollars, can be determined by the following equation:

$$1{,}762\,Y = 1{,}000\,X$$
$$Y = \frac{1{,}000\,X}{1{,}762}$$
$$= .567\,X$$

where Y = one 1985 dollar
X = one 1980 dollar

* "Compounded annually" means that one year after the deposit is made, 12% interest is credited to the investor's account. In the second year interest is paid on the initial principal plus the interest deposited at the end of the first year and so on until the agreement terminates.

In other words, assuming that the investor can earn a twelve percent interest rate, the present worth of one 1985 dollar is 56.7 cents. Under these assumptions, if you put 56.7 cents in the bank today, you get $1.00 in 1985. Therefore you should only be willing to pay 56.7 cents today for the privilege of receiving $1.00 in 1985. Equally that 56.7 cent investment today is sufficient to meet a foreseen expenditure of $1.00 in 1985.

In any project analysis, therefore, all future benefits and costs must be discounted back to the present to find their present worth, using an appropriate discount rate or interest rate.* Only in this way can the long-term implications of the project be adequately assessed.

Discounting for present worth

The actual discounting calculation is fairly simple. The present worth of a future expenditure of one dollar is calculated using the following formula:

$$PWF = \frac{1}{(1+r)^t}$$

where r = discount rate
t = number of years from today that the cash flow occurs
PWF = present worth factor

and arises out of the compounding formula for interest. One dollar in the bank today at 12% interest, in one year returns $(1 + r)$ $1.00 = $(1 + .12)$ $1.00 = $1.12 where r is the rate of interest. If the $1.12 is left there to compound for one more year, the return is $(1.00 + .12)$ $1.12 = $1.254 = $(1.12)\ (1.12)$ $1.00. In general, in year t, returns would be $(1 + r)^t$ $1.00. The present worth of a dollar received in year t, is calculated by simply inverting to get the formula:

$$\frac{1}{(1+r)^t}$$

* In this chapter the terms interest rate and discount rate are used more or less interchangeably. Sources listed in the bibliography provide a more complete discussion.

4- Using Discounted Cash Flow Analysis to Minimize Costs

Discounted cash flow analysis (DCF) provides a basis for calculating present worth by using an appropriate discount rate.* By determining the present worth of future costs and benefits, a DCF calculation can answer a problem raised earlier, whether or not additional capital expenditures lower annual operating expenditures sufficiently to make an investment worthwhile.

It also answers the equivalent question raised by the insulation project set out below:

- which project among competing alternatives will provide the same service for the lowest total costs (over the life of the project).

In the example illustrated below, two alternative choices provide identical services with a different mixture of capital and OMA energy costs. Which of the two will provide a comfortable environment for the lowest cost, Project A, or Project B?

TABLE 2

Project: $100 Investment in insulation

	Project A Insulate	Project B Do Nothing
Investment	$100	0
Annual Energy Costs	$ 20	$50
Time Horizon	20 years	20 years

Projects A and B have different patterns of expenditure. Project A requires initial expenditures of $100; Project B involves nothing. Project A has higher capital costs but lower annual energy costs. Should we say that Project A is more costly than Project B? If we did, we would be ignoring the fact that by opting for Project B we will commit the municipality to energy costs

* Discounted cash flow can also be used to evaluate decisions where the benefits as well the costs of the projects are different, as long as adequate quantitative estimates of the value of project benefits can be constructed (see "Net Present Value").

of \$50 per year, \$30 a year more than the \$20 required by Project A.

Another approach would simply be to add up all the costs of each project over the life of the investment. In this case, Project A involves an expenditure of \$500. Project B adds up to an expenditure of \$1,000. Again this method is not satisfactory, because it ignores the fact that a dollar tommorow is worth less than a dollar today.

A correct approach is to determine the present worth of the two alternative projects. To do so, each year's cash flow has to be converted to its present worth and then added up. Assuming 12% is an appropriate rate to discount (or trade) tommorow's dollars for today's dollars, Table 3 illustrates the calculations that determine the total discounted cost or the present worth of Project A in the previous example.

The present worth of total expenditures for Project A is \$249.38. The present worth of expenditures associated with Project B, doing equivalent calculations, is \$373.45. The lowest cost project in terms of discounted dollars is Project A. Therefore it would be cost-effective to invest the \$100 in the insulation.

One way of visualizing the significance of these numbers is to imagine that you are going to prepay today your heating costs for the next twenty years. If you choose to invest in the insulation project, you will immediately pay out \$249.38 to cover both the capital cost and all energy costs. If you choose not to insulate, you will make a payment of \$373.45 to cover the energy costs alone.

The discounted cash flow techniques allow the analyst to identify the lowest cost project. It must be emphasized, however, that the projects being compared above offer identical services and benefits. Therefore, only costs need to be considered because the benefits (e.g., a warm building) are identical. Later in this chapter this analysis will be expanded to allow a simultaneous consideration of costs and different benefits.

5- Choosing a Discount Rate for Project Evaluation

The discount rate should be carefully chosen. The choice of projects can be greatly influenced by the rate selected, and project ranking can change with changes in the discount rate. That is, at one discount rate Project A may be better than Project B; at another discount rate the reverse will be true.

The lower the discount rate the more investment will be justified today to save energy in the future. This is because the present value of future savings will change inversely to the discount rate.

In the formula $\frac{1}{(1 + r)^t}$

(where t is the number of years from the present that the cost is incurred) the larger the discount or interest rate, the larger is the denominator and the smaller is the present worth factor. Thus, five years from now, if the discount rate is 12% then the denominator equals

$$(1.12) \times (1.12) \times (1.12) \times (1.12) \times (1.12) = 1.7623$$

$$\text{and} \quad \frac{1}{(1.12)^5} = \frac{1}{1.76} = .5674$$

However, if the discount rate is only 6% the denominator in year five will be

$$(1.06) \times (1.06) \times (1.06) \times (1.06) \times (1.06) = 1.338$$

$$\text{and} \quad \frac{1}{(1.06)^5} = .7473$$

The present worth of \$100 in year five will be only \$56.74 if the discount rate is 12%, but \$74.73 if the discount rate is 6%. A high rate of discount means that costs or benefits occurring in the future have a much lower weight attached to them than if a lower discount or interest rate were used.

The choice of a discount rate is a contentious issue in both business and economic literature. At a minimum, it is recommended that the cost of long-term funds to the municipality be used as the discount rate. Using this rate will minimize the present value of expenditures to the municipality over the life of the project. The rate applied may for instance reflect the rate on long-term bonds or long-term bank loans available at the time the project is being considered.

TABLE 3

Project A: $100 Investment in Insulation

Discounted Cash Flow Analysis to Determine Present Worth

Calendar Years	1 Years from Present Date	2 Project Cash Flow	3 Present Worth Factor	4 Present Worth of Cash Flow col 2 x col 3
1980	0	$100	$\frac{1}{(1+.12)^0} = 1$	$100
81	1	$ 20	$\frac{1}{(1+.12)} = .893$	$ 17.86
82	2	$ 20	$\frac{1}{(1+.12)^2} = .797$	$ 15.94
83	3	$ 20	$\frac{1}{(1+.12)^3} = .712$	$ 14.24
84	4	$ 20	$\frac{1}{(1+.12)^4} = .636$	$ 12.72
""	""	""	""	""
2000	20	$ 20	$\frac{1}{(1+.12)^{20}} = .104$	$ 2.08
Sum		$500		$249.38 *

* This equals $100 (the present worth of the initial capital expenditure of $100) + $149.38, which is the present worth of the energy expenditures from year 1 to year 20.

One pitfall that should be avoided is using the average cost of existing debt or loans as the discount rate. Interest rates contracted for in the past may have little relationship to interest rates now available. It is the current cost of borrowed funds that is needed to correctly evaluate a new proposal. The municipality's comptroller should have a reasonable idea as to what the current cost of funds would be.

6- Project Analysis and Inflation

A number of factors complicate forecasts of future prices and cash flows. First, inflation has become built into the economy, producing price increases for individual products or resources whose magnitude and timing are difficult to predict. Energy prices are volatile on the international market. While domestic energy prices are subject to provincial and federal regulation, they are also influenced by international events.

Basically, inflation is the change in the purchasing power of currency. If the inflation rate is 10%, then it will take $550 in 1981 to buy goods and services equivalent to $500 in 1980. Inflation prevents a dollar received in 1981 from having the same value, in terms of what it can buy in 1981, as a dollar received in 1980. Consequently, when estimating cash receipts and expenditures that occur at different times, it is necessary to ensure that dollar amounts are adjusted to account for changes in purchasing power.

In Canada, we can expect energy prices to rise at rates higher than the general rate of inflation. In project analyses, therefore, it is important to allow for inflation in a consistent manner in all calculations.

The current market interest rate, recommended here as a minimum discount rate, reflects the fact that lenders of funds expect inflation to continue. Consequently, the cash payments they receive in the future will be devalued because the purchasing power of the dollar has declined. Compensation is therefore built into the market interest rate for the expected change in the price level.

Since inflation is built into the market rate of interest at which the municipality borrows, it is necessary to ensure that municipal estimates of future prices also reflect expected inflation. If inflation is not built into these forecasted prices, some projects which should proceed may be rejected because inflation is counted in one part of the analysis but not the other.

How inflation affects the interest rate

Suppose for example a 3% real rate of return was necessary before you would be willing to lend money for one year. Further assume that the inflation rate will be 10%. The size of the prospective loan is $500.

The analysis should proceed as follows:

Principal: $500
Compensation for 10% inflation on principal

.10 X 500 = $50.00

(Note that we can express an interest rate of 10% as a decimal fraction .10)

Real interest on capital of 3%

.03 X 500 = $15.00

Compensation for 10% inflation on the return earned on investment (to maintain the real value of the return)

.10 X 15.00 = $1.50

Total required	$50.00
Return on loan	$15.00
	$ 1.50
	$66.50

Rather than using these separate calculations, however, the rate of inflation can be multiplied by the required real rate of return to get an appropriate interest rate for the lender to charge on the loan.

Calculation:

$$
\begin{aligned}
& (1 + \text{inflation rate})\ (1 + \text{real rate}) \\
= \; & (1 + 0.1)\ (1 + 0.03) \\
= \; & (1 + .03 + .1 + .003) \\
= \; & (1 + .133)
\end{aligned}
$$

Multiplying the principal by $500 by .133 yields $66.50.

Thus a discount rate of 13.3% would ensure a return on investment which compensates both for the expected decline in purchasing power by 10% per annum inflation and for foregoing other opportunities.

Secondly, along with general increases in prices, significant additional rises can be expected in the price of energy. At present it is reasonable to predict that the price of energy will rise faster than that of other products. Thus, the real price of energy will rise, and this additional change in energy prices should be built into the analysis.

To summarize, since the market rate of interest includes an allowance for inflation, projections of other prices and costs should allow for inflation in a consistent fashion, as well as for changes in the price of energy relative to other commodities.

7- Net Present Value - An Alternative Evaluation Technique

An equivalent but sometimes more convenient way of looking at energy projects is to view energy savings as 'benefits' which can be compared with the additional capital and operating/maintenance expenditures required to realize these benefits.* To compare them, both benefits and costs are discounted back to the present. A project is worthwhile if the (discounted) benefits exceed the (discounted) costs; that is, if the net present value is positive.

A comparison based on benefits and costs can be more applicable for project analysis than one based on costs alone - in many cases projects being compared offer very different benefits. Again two questions are usually asked about any project:

- o Should the project be undertaken?
- o Is the project better than a competing project?

Table 2 showed that the municipality would save $30 per year by investing in insulation, since energy costs would be reduced from $50 per year to $20 per year. These savings are the benefits from the project.

* The discounted cash flow technique is still being used. The problem, however, has been restated.

TABLE 4

PROJECT: $100 INVESTMENT IN INSULATION
CALCULATION OF NET PRESENT VALUE

Calendar Years	Year From Present Date	Project Costs	Project Benefits	Present Worth of Costs	Present Worth of Benefits
1980	0	$100	0	$100	
81	1	0	$30		26.79
82	2	0	$30		23.92
83	3	0	$30		21.35
84	4	0	$30		19.07
"	"	"	"		"
2000	20	0	$30		$ 3.11
		$100	$600	$100	$224.08

Net Present Value = $224.08 - $100.00

= $124.08

When discounted, these benefits can be compared to the capital costs of the project to determine if it is worth undertaking. The present value of the energy dollars saved is compared to the present value of costs.

Using the same insulation project as an example, Table 4 illustrates the calculation of net present value. The project cost is $100 spent in project year 0. The benefits of the project are the value of energy savings that will be realized by the municipality.

The basic rule is to proceed with projects whose net present value (NPV) is positive. That is, proceed with projects where net present value (present worth of benefits minus present worth of costs) is greater than zero.

In the example, the present worth of benefits is $224.08. The present worth of costs is $100. The net present value is $124.08. Therefore the project should proceed. If the municipality borrows $100 at 12% over twenty years to finance a project, annual payments of principal and interest would be $13.39. Since the municipality is reducing its energy expenditures by $30 per year, the savings would allow repayment of the principal and interest and leave something left over to be spent on other services.

The net present value approach to capital budgeting problems can be used to assess a wide range of problems. In a situation where two projects are mutually exclusive (e.g. only one type of lighting system can be installed) the problem is to pick the most desirable of the two. Where services produced are essentially identical, the project with the largest net present value will be the project that minimizes the discounted costs of providing these services.

In other cases, projects with different benefits and different costs will be examined. In such situations, asking for the lowest cost project is not relevant. For instance, in a project to improve the energy efficiency of a street lighting system, the benefits will be the present value of the energy saved in future operation of the system. If another project involves improving a boiler in a building, then the benefits will be the value of the energy saved in providing heat to the building. Because the services provided by these projects are not identical, these projects cannot be compared on the basis of costs alone. The correct approach would be to calculate the net present value of each separate project and then compare net benefits.

Similarly the NPV approach can be used to compare a capital project which will reduce labor costs and an investment which will reduce energy costs. Once again the benefits of each project are very different. The net present value of each project can be calculated to see which is larger. Ideally, if both projects have a positive net present value, both should be undertaken.

Finally, so long as benefits and costs can be satisfactorily quantified, then useful comparisons are possible between very different projects - a choice, for instance, between constructing a new park and constructing a new arterial road. This of course takes us beyond considerations for energy conservation programs*.

8- The Problem of Different Life Expectancies

A difficult analytical problem sometimes arises with mutually exclusive investment possibilities with different lifetimes. This particular problem can occur in a choice between buildings with different lifetimes. The problem is to decide between a low capital cost, high operating cost, short-lived building or a high capital cost, low operating cost, long-lived building. Similarly, in the transportation sector, the choice might lie between vehicle fleets - a gas-saving fleet with shorter vehicle life and higher maintenance costs versus a fleet with higher fuel costs, lower maintenance and longer vehicle life.

One approach suitable for such situations would be to lengthen the time horizon to allow for repetition of the shorter-lived investment. For instance, if one set of vehicles has a life of three years and an alternative set four years, the present

* Non-quantifiable benefits of a program may be very important. For example, a project which creates new jobs in a community facing serious unemployment has important benefits in terms of community stability and security, but these are less easily quantified than the payroll costs to the municipality.

value analysis could be conducted for twelve years, allowing for the capital expenditures necessary to replace the retired equipment in each case. This does not mean, if the shorter-lived investment is chosen, that at the end of three years the fleet would be replaced automatically with identical vehicles. When the equipment life comes to an end, prices or interest rates will have changed and it could be advantageous at that point to change the equipment configuration.

9- Calculating Project Costs - A Cautionary Note

So far it has been assumed that cash outlays associated with a project represent costs of using or committing resources for that project. There are times, however, when this assumption is misleading and can lead to poor decisions.

A good illustration of this problem is the evaluation of a proposal to build at a particular location. Suppose the municipality owns the land. Does this mean that because there is no cash expenditure for land purchase no cost should be imputed to the site?

The answer depends upon the particular circumstances. If the municipality could sell the land to the private sector, then the market value of the land is the opportunity cost of using the land, and should be considered. Failure to appropriately value the land in terms of its current market value will obscure the assessment of costs and benefits. Similarly, if the site were purchased five years earlier, the historical cost of the purchase would not necessarily be the market value today. Only the current market value would represent the opportunity cost to the municipality of employing the resource.

Where a durable asset which has already been acquired (e.g. a building, a piece of equipment, or a parcel of land) is utilized in a project, then the appropriate estimate of the cost of employing the asset cannot be based on the historical cost of the asset, historical cost less depreciation, or any accounting value of the asset. What counts is current opportunities for using the asset.

If there are no other opportunities, now or in the future, the opportunity cost is zero and the asset should be treated as free for project evaluation. If there are other opportunities, it is the most highly valued alternative use that determines the cost of employing the asset.

10- Social Benefits and Social Costs

This discussion is based on the idea that trade-offs must be made between capital expenditures now and energy expenditures in the future. Up to this point it has been assumed that local governments choose between alternative projects to minimize costs over the life of the projects. In other words, this section has mostly dealt with trade-offs of energy and capital for internal municipal operations.

Trade-offs, however, occur in other areas as well. In many cases the choice involves higher capital expenditures (and possibly operating expenditures) in exchange for lower energy costs for the residents of the municipality. For instance, a decision to build an arterial road may lower the gasoline and time costs of residents traveling to work. This is one example of the general problem of evaluating municipal projects which affect the residents of the community.

It has already been pointed out that past expenditures on the municipal books (e.g. for land) would sometimes fail to reflect actual opportunity costs of using these resources. Likewise, to return to the example of the arterial road, neither benefits to drivers nor costs of noise pollution to the homes bordering the roadway will be reflected in the accounts of the municipality.

Any project with community impact, whether it creates burdens or confers benefits for community members, results in costs and benefits to individuals which are not reflected in the municipality's internal cash flows. Governments should therefore take account of the costs and benefits to all individuals, even when these effects do not show up as cash transactions.

The difficulty in assessing benefits or costs of such projects arises because they cannot be directly measured in dollar terms. This problem derives from the lack of markets which would provide objective indications, and quantitative measures, of the value placed by individuals on these costs or benefits. Consequently they cannot be evaluated by a decision-making process which only assesses actual dollar values.

In addition, the distribution of burdens and benefits can vary widely from project to project. For instance, if a municipality is deciding whether to build a new park or a new road, a comparison of the dollar expenditures for construction of the two projects does not allow an assessment of whether one project is better than the other. In one case you benefit a portion of the driving population; in the other you benefit the families who will make use of the new park facility. The services and beneficiaries of the projects are different.

Whether you forego the benefits of the park to reap community energy savings from the new road, or whether you choose the park over the road, may be a difficult question to decide. It may be impossible to quantify the value of the recreation services that a park would provide to the community. It may also be impossible to quantify the net benefits of the new road. However, a decision-maker must ensure that both positive and negative effects of each project are identified and assessed to the extent possible.

Not all projects with community impacts will be quite so difficult. If a choice has to be made between a stoplight and an elevated crossing, both presumably provide the same service - safety for pedestrians. However, the stoplight may interrupt traffic flows, increasing gasoline consumption and driving time.

To evaluate whether the additional costs of the crossing are worthwhile is a case of trading off capital for energy. In this case, however, the energy savings appear in the pockets of the residents, not on the books of the municipality. In principle an analyst can evaluate the benefits of the project (i.e. the value of the gasoline saved per year and the value of the time saved per year) then discount these yearly savings back to the present. This indicates whether the discounted benefits exceed the additional costs of installing the elevated crossing instead of the stop light.

These are not purely questions of economic efficiency. Some benefits, the savings in gasoline, are not readily apparent and others, the increase in pedestrian safety, affect only a few individuals. Different sections of the community will place different priorities on the services they expect the municipality to provide. Decision-making for projects with visible community impact will therefore be based on many considerations.

This discussion barely scratches the surface of social cost benefit analysis. Some projects may be sufficiently important to warrant the hiring of consultants to conduct social cost benefit analyses*. The techniques used in such studies will be closely related to those described in this section. For the official evaluating such studies, the critical problem is to pick out the implicit assumptions used to construct the estimates of costs and benefits.

---

* If municipal staff is familiar with cost benefit analysis, it can be done in-house.

PROBLEM : TO ESTABLISH THE MOST COST EFFECTIVE WALL INSULATION LEVEL FOR A NEW BUILDING

OPTIMIZING INSULATION

Project Numbers	Insulation Thickness mm	Annual Consumption kWh* per sq metre***	Initial Year Energy Costs $/sq metre	Capital Cost $/sq metre***	Additional Capital Costs	Present Value of Energy Costs	Reduction in Present Value of Energy Costs	Total Discounted Costs** (Capital costs and present value of energy costs)
1	50	6.35	.75	9.04		13.67		22.71
					2.15		6.78	
2	100	3.18	.38	11.19		6.89		18.08
					2.15		2.37	
3	150	2.12	.25	13.34		4.52		17.86
					2.15		1.08	
4	200	1.59	.19	15.49		3.44		18.93

The following assumptions are made:

Life of project	20 years
Escalation rate in the cost of electricity	9%
Interest rate	10%

Source: Numerical Calculations from Energy Conservation Design Resource Handbook, Royal Architectural Institute

SOLUTION The total costs of each alternative project are displayed in column 9. The best insulation level is chosen by picking the level of insulation which produces the lowest total discounted costs, in this case $17.86.

* kWh = kilowatt hour of electricity

** The total cost is the total present value or the total life cycle costs.

*** Can be calculated by Engineer. Because results will be obtained by multiplying the area of the wall to be insulated by the appropriate per unit costs, the calculation is based on per unit (square metre) measures.

EXPLANATION:

First, the total present value of all expenditures associated with different insulation thicknesses is calculated.

From the table (column 6) we can see that to increase insulation thickness by 50 mm* costs an additional $2.15 per sq metre for insulation thickness in the range between 50 and 200 mm. However, the effect of the additional insulation on energy consumption diminishes. Increasing insulation from 50 to 100 mm reduces electricity consumption by 3.17 kWh (6.35-3.18). However increasing insulation from 150 to 200 mm only reduces consumption by .53 kWh (per sq. metre). Thus while additional capital costs are constant (at $2.15 per 50mm), additional energy savings decline.

* Fifty millimetres (mm) is approximately 2 inches.

The value of additional savings is computed in column 8. By increasing insulation from 50 to 100 mm the value of the benefits, that is the reduction in the present value of the energy costs, will be $13.67 - $6.89 = $6.78. Thus by spending an additional $2.15 we have reduced our energy costs (over the life of the project) by $6.78. Clearly this is an advantageous investment.

Performing this same calculation for an increase in insulation from 100 mm to 150 mm, the present value of energy costs declines from $6.89 to $4.52 for a benefit of $2.37 against an additional cost of $2.15. The value of the additional savings exceeds the additional capital expenditure. If we increase insulation thickness from 150 mm to 200 mm, however, the benefit is only $1.08 while the additional cost is still $2.15. In such a case the additional costs exceed the added benefits and further investment in insulation is not warranted. The appropriate level of insulation is the point where the additional costs roughly equal additional benefits ($2.37 is roughly equal to $2.15. in this context).

Sources:

Bierman, Harold and Smist, Seymour. The Capital Budgeting Decision (Third Edition). Collier-MacMillan Publishers, New York: 1971.

Mishan, E.J. Cost Benefit Analysis. George Allen and Unwin Ltd., London, 1977.

Quirin, G. David. The Capital Expenditure Decision. Richard D. Irwin Inc.: Homewood Illinois, 1967.